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# Pandemic Dreams: Network Analysis of Dream Content During the COVID-19 Lockdown

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We used crowdsourcing (CS) to examine how COVID-19 lockdown affects the content of dreams and nightmares. The CS took place on the sixth week of the lockdown. Over the course of 1 week, 4,275 respondents (mean age 43, SD = 14 years) assessed their sleep, and 811 reported their dream content. Overall, respondents slept substantially more (54.2%) but reported an average increase of awakenings (28.6%) and nightmares (26%) from the pre-pandemic situation. We transcribed the content of the dreams into word lists and performed unsupervised computational network and cluster analysis of word associations, which suggested 33 dream clusters including 20 bad dream clusters, of which 55% were pandemic-specific (e.g., Disease Management, Disregard of Distancing, Elderly in Trouble). The dream-association networks were more accentuated for those who reported an increase in perceived stress. This CS survey on dream-association networks and pandemic stress introduces novel, collectively shared COVID-19 bad dream contents.

Keywords: dream, sleep, crowdsourcing, cluster, network analysis, COVID-19, nightmare, stress

## INTRODUCTION

On March 11, 2020, the World Health Organization announced that COVID-19 is a pandemic (World Health Organization, 2020). Significant events and threatening situations change the way people sleep and dream, and pandemics are no exception (Nielsen et al., 2006; Hartmann and Brezler, 2008; Sandman et al., 2013; Cenat et al., 2020). While sporadic changes in sleep and dreaming are normal, and sleep naturally responds to environmental fluctuation, extreme factors and traumatic experiences can lead to severe changes in sleep patterns, including altered dream content or more nightmares. An increase in nightmares has been previously observed with regard to wars, terrorist attacks, and during earlier pandemics or infectious diseases (Nielsen et al., 2006; Hartmann and Brezler, 2008; Sandman et al., 2013). Similarly, the COVID-19 pandemic poses a threat to health and well-being, causes worries and fears, alters behavior and everyday life, and has a lasting impact on how we perceive the world (Zhou et al., 2020). Thus far, preliminary reports suggest that poor-quality sleep and insomnia-related symptoms have indeed increased in

the general population (Casagrande et al., 2020; Huang and Zhao, 2020; Xiao et al., 2020); however, the impact of the pandemic on the content of dreams and nightmares remains unexplored. Seizing on the opportunity and collecting dream content during a carefully selected time window during the COVID-19 lockdown allowed for a unique natural experiment to study dreams and nightmares.

Indeed, dreams reflect waking consciousness by spontaneously incorporating daytime experience (Koulakos et al., 1985; Stickgold et al., 2000; Nielsen et al., 2004; Malinowski and Horton, 2014; Solomonova et al., 2015). Evidence converges to suggest that the incorporation of experience into dreams is characterized by a case of a process, such that dreams include events from both the preceding day (day-residue effect) and a week earlier (dream lag effect) (Nielsen et al., 2004). In order to understand whether the stress of the pandemic influences dreams and results in collectively shared dream content (i.e., whether shared experiences, such as COVID-19 and the lockdown, produce similar dreams), it is crucial to solicit the dream reports during a very short timeframe.

Nightmares are a special case of dreaming. They can be defined as repeated occurrences of extended, extremely dysphoric, and well-remembered dreams that usually involve threats to survival, security, or physical integrity (American Psychiatric Association, 2013). Current definitions acknowledge that many nightmares are not followed by an awakening (American Psychiatric Association, 2013). While occasional nightmares are common and harmless, frequent nightmares have been associated with other sleep problems (Zadra and Donderi, 2000), symptoms of depression (Li et al., 2010), and even increased risk of suicide (Russell et al., 2019). Idiopathic nightmares can contain events and themes that reflect daytime experiences, but they are rarely repetitive or replicate events accurately (Gieselmann et al., 2019). Post-traumatic nightmares, on the other hand, have a clear relation to previously experienced traumatic events and may even replicate parts of the trauma in detail (Sandman et al., 2013; Miller et al., 2017). The COVID-19 pandemic and the lockdown had potential to generate both types of nightmares, depending on the circumstances of the dreamer.

The current study used a crowdsourcing (CS) method to investigate how COVID-19 lockdown is associated with self-reported changes in perceived stress and increases in nightmares or deviations in dream content. We took the opportunity to ask respondents to describe the content of their dreams during the lockdown and then applied computational network and cluster analyses to find clustered word-association chains commonly occurring in the data. In keeping with the dream continuity hypothesis (Schredl and Hofmann, 2003), we expected dreams to exhibit novel thematic categories specifically related to the current pandemic lockdown.

Perceived stress levels increased in the majority (56%) of respondents [high increase in 767 (18.0%), whereas 1,620 (38.0%) reported a modest increase]. A total of 933 (21.9%) respondents reported unchanged, and 943 (22.1%) reported lowered stress. Stress levels increased in more females than males ( $P < 0.001$ ). The pandemic's impact on sleep patterns was assessed in terms of sleep duration, sleep latency, awakenings, the regularity of the sleep rhythm, and the frequency of nightmares (Table 2). Females were more likely than males to report increased sleep duration and more frequent nightmares ( $P < 0.001$  and  $P < 0.001$ , respectively). An increase in perceived stress levels was associated with progressively shorter sleep durations ( $r_s = 0.26$ ,  $P < 0.001$ ), prolonged sleep latency ( $r_s = 0.37$ ,  $P < 0.001$ ), more frequent nightly awakenings ( $r_s = 0.43$ ,  $P < 0.001$ ), increasingly irregular sleep rhythms ( $r_s = 0.182$ ,  $P < 0.001$ ), and more frequent nightmares ( $r_s = 0.29$ ,  $P < 0.001$ ). Figure 1 displays the prevalence of sleep disturbances in relation to respondents' perceived levels of stress. Increased disturbances

TABLE 1 | Age distribution of the sample.

Years	N	%
<20	75	2.2
20–34	1051	30.1
35–49	1273	36.5
50–64	824	23.6
65	264	7.6

798 respondents did not report age.

TABLE 2 | Change in sleep patterns from pre-COVID-19 to lockdown.

	Sleep duration	Sleep latency	Awakenings	Sleep regularity	Nightmares
Decreased (%)	16.6	13.0	11.7	16.3	3.5
No change (%)	29.1	77.4	59.7	53.8	70.4
Increased (%)	54.2	9.6	28.6	29.9	26.0

Lockdown-associated sleep changes per respondent

Number of sleep items	1	2	3	4	5
Complaints (%)	24.0	15.6	8.7	3.1	0.6
Improvements (%)	32.1	20.8	8.7	2.6	0.4

## RESULTS

### Sample Characteristics

There were 4,275 citizens who participated in the CS (mean age 42.6, SD = 13.7 years, range 10–99, 79% women, 10% men, 2% other/unspecified) over the course of 1 week, and 811 respondents reported their dream content. The age distribution of the participants is shown in Table 1. The majority (57.5%) were employed and worked from home, and the remainder had the following distribution: 12% working outside the home; 10.2% students; 8.6% retired; 8.7% unemployed/laid off; and 3.2% other.

FIGURE 1 | The percentage of individuals reporting worsening sleep (shorter sleep duration, longer sleep latency, more awakenings, disturbed circadian rhythm, and more nightmares) according to their experience of COVID-19-related stress.

were concentrated primarily in those who reported a high increase in stress; their sleep worsened linearly with the increase in perceived stress. The most prominent increases were for nightly awakenings (60.5%) and nightmares (45.8%) in the groups with the highest perceived stress.

Regarding beneficial effects, those with lowered stress levels during the lockdown reported longer sleep duration (73.9%) and more regular sleep rhythm (44.9%) compared to their pre-pandemic sleep.

## Dream Content Frequencies and Networks

Dreams were reported by different frequencies in different stress groups (high increase in stress = 27.4.5%; moderate increase in stress = 20.5%; stress unchanged = 13.0%; stress lowered = 17.8%),  $\chi^2 = 58.427, P < 0.001$ . Age was not associated with the likelihood of reporting dreams ( $P = 0.087$ ). Females were more likely to report dream content than males ( $\chi^2 = 72.423, P < 0.001$ ; 21.6 and 9.6%, respectively). In addition, working status differed between dream reporters and non-reporters ( $\chi^2 = 23.022, P < 0.001$ ). Students and retired persons were more likely to deliver a dream report, whereas those working remotely were less likely to do so (Supplementary Figure S1).

Figure 2 displays the most frequent words in the dream report data: column 1 for “stress increased” (words related to themes that could be clearly identified through their death, work, modest or high increase responses combined) and column 2 for “Stress-unchanged/lowered” (words included large association networks of different pandemic-friend, coronavirus-associated threats and landscapes).

Next, we created an unsupervised network analysis in which word associations are displayed in a correlation network. Unsupervised cluster analysis suggested 33 dream clusters, all of the groups combined, 27 in the “stress increased” group.



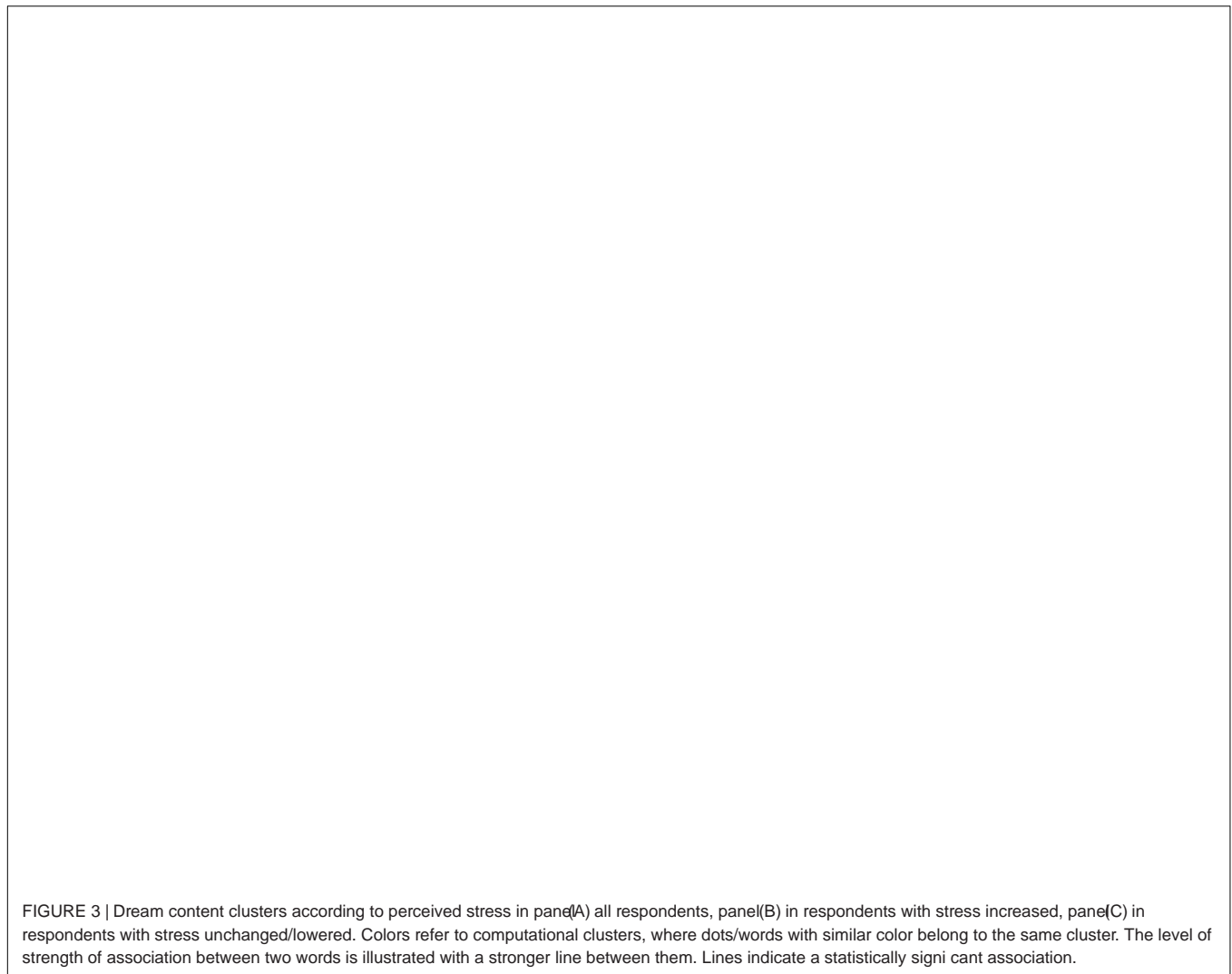
help (in the group where stress was increased); ~~darkness~~ The impact of lockdown on sleep quality was twofold. The return, dog (in the group where stress was unchanged/lowered) majority of the respondents reported having a longer sleep duration, and almost a third reported having more regular sleep rhythms during the lockdown compared to the pre-lockdown situation, likely reflecting alleviated pressure in scheduling due to working from home. Lockdown-related sleep complaints were also common: almost a third reported more frequent awakenings at night, and more than a quarter of the respondents also reported an increase in nightmares. As could be expected (Nielsen et al., 2006; Nielsen and Levin, 2007; Robert and Zadra, 2014), we observed a larger increase in the frequency of nightmares among respondents who also reported elevated stress during the lockdown, although no causality can be inferred.

re-acted conventional nightmare/bad dream content.

## DISCUSSION

We explored sleep patterns and pandemic dream content during the sixth week of the lockdown. Instead of traditional a priori-defined thematic content analysis of dreams, we used a computational exploratory, unsupervised network analysis to identify 33 different dream clusters (in all respondents), of which 20 were evaluated as having distressing dream content (Pons and Latapy, 2005). These networks were clustered based on the association networks around single words. The resulting dream clusters allowed identification of novel and commonly shared dream content during a time-restricted lockdown period.

Our analysis of dream content revealed typical, idiopathic nightmares/bad dreams (e.g., falling, being chased, being late, and the deaths of loved ones) (Robert and Zadra, 2014), comparable to nightmares reported in a very similarly aged population-representative sample in 2010 (mean age = 46, SD = 16 years) (Schredl, 2010). Health-related concerns represented 12% of the distressing dream content in the general population (Robert and Zadra, 2014). In the current study, we identified 33 different dream clusters (in all respondents), of which 20 were evaluated as having distressing dream content, and of these, 55% were pandemic-specific. Themes such as failures in social distancing, coronavirus contagion, personal protective equipment (PPE), dystopia, and apocalypse were identified as pandemic-specific. Most of these were confounded with established idiopathic dream categories (e.g., failure, death,



worry), but the dream imagery was specific to the current concerns (Hartmann, 1998; Hartmann and Brezler, 2008). In line with that, our analytical approach to associative dream

Sleep enables online processing of recent memory traces and content networks was particularly insightful in terms of revealing pandemic-specific dream imagery, as we detected some central memories through a physiological reactivation of brain areas (e.g., surgery, PPE) that may refer to fear but were recruited during learning (Klinzing et al., 2019), as activation is contextualized in varying dream events. Overall the findings from analysis of dream content are consistent with threat simulation theory (Revonsuo, 2000) and the dream continuity hypothesis (Schredl and Hofmann, 2003), as we identified dreams (often experienced in bad dreams, idiopathic nightmares, and post-traumatic nightmares) associated with emotional arousal that potentially prepare the dreamer for negative events that may can equally serve to extinction of fear memories (Nielsen and Levin, 2007) and would then assist in the emotional adaptation to the presence of COVID-19, as REM sleep plays a critical role in emotional processing (Tempesta et al., 2018). Comparing the dream-association networks according to perceived (daytime) stress, we found fewer repeated associations in networks in the “stress unchanged/lowered” group, but roughly half of the dream-association networks were still pandemic-specific, as was also the case in the “stress increased” group.

Hartmann's contextualizing hypothesis proposes that the most frequent dream words were corona[virus], crowd, and death among those with increased stress levels, and friend, a picture context for, an individual's predominant emotional and corona[virus] among those with unchanged/lowered stress



TABLE 3 | Dream cluster labels according to perceived stress.

All respondents	Stress increased	Stress unchanged/lowered
1. *Travel Dif culties, overcrowding	1. *Travel Dif culties, overcrowding	1. *Disregard of distancing
2. *Disregard of distancing	2. *Falling	2. *Obstacles in returning home
3. *Surgery and troubles	3. *Murder in the night	3. Care of family
4. Travel	4. *Elderly in trouble	4. *Falling into dark water
5. *Violence with weapons	5. *Disregard of distancing	5. *Chase-escape
6. *Quarantine and disease symptoms	6. *Apocalypse	6. *Being lost in a city
7. *War	7. *Crowd-restriction	7. *Isolation anxiety
8. *Apocalypse	8. *Chase-escape in war and borders	8. *Coronavirus contagion
9. Body and hair	9. *Searching the lost	9. People from past
10. Touch	10. *Un nished task	10. *Death of loved one
11. Nightly surprise	11. *Transport accident	11. School party
12. *Elderly in trouble	12. *Being in danger and shouting	4/9 of mainly distressing dream clusters are pandemic-speci c (44%)
13. *Fire	13. *Being late	
14. *Un nished task	14. *Patient care, cough	
15. Deceased grandmother	15. *Personal protective equipment	
16. *Toilet and queuing	16. Father	
17. *Burglary	17. City landscape	
18. *Being late	18. Travel	
19. Concert	19. *Exam	
20. *Event cancellation	20. Discussion with parent	
21. Homeschool	21. *Dystopia	
22. Sister visit	22. *Coronavirus contagion	
23. Being drunk	23. *Event cancellation	
24. *Quarrel with spouse	24. People from past	
25. *Coronavirus contagion	25. *Death of loved one	
26. Cheating in relationship	26. *Quarrel with spouse	
27. *Lockdown	27. Problem solution	
28. *Car accident	11/21 of mainly distressing dream clusters are pandemic-speci c (52%)	
29. *Death of loved one		
30. People from past		
31. Travel abroad		
32. *Shame in public place		
33. Drinking alcohol		
11/20 of mainly distressing dream clusters are pandemic-speci c (55%)		

Bolded labels rated as pandemic-speci c. \*Bad dreams or nightmares.

levels. This would suggest that the pandemic has a substantial impact on the content of dreams independently of perceived stress. However, the available information could not distinguish between post-traumatic nightmares and the incorporation of waking events and worries into the dream context without a related emotion.

A particular strength of the study is in computational analysis of the dream reports. The analyses of dream reports with unsupervised algorithms were then free from a priori defined dream categories. As another asset of this study, the CS was open

only during 1 week, allowing investigation of time-bound dream content in relation to the progress of the COVID-19 lockdown. Just 10 days after the CS ended, the COVID-19 restrictions were partly lifted (for example, schools were reopened). The time-bound nature of the CS is important as dreaming is thought to constitute a valuable model for the study of consciousness with implications beyond sleep (Siclari et al., 2017). This is because in normal sleep we are at least partly disconnected from environmental input and from performance of any tasks. The current approach may also be inspected from the perspective of dreams as a collectively shared consciousness during the COVID-19 lockdown.

In the same vein, these interpretations are also limited by a number of methodological constraints. Dream reports are never fully accurate, and they are confounded by a number of factors: elapsed time, memories, other dreams, forgetting, and translation to a verbal narrative (Waterman et al., 1993; Windt, 2010). Some people recall very specific and visually rich dreams, whereas the dream reports of others contain only one specific dream event, such as being chased. The newspaper article on stress and nightmares published jointly with the invitation to the CS questionnaire may also, apart from inspiring respondents to report their dreams, cause systemic bias. In addition, our classification of nightmares/bad dreams was not based on subject ratings, as is typically the case; rather, our panel of judges made qualitative judgments as to whether or not dreams were distressing. The CS might have attracted more responders with sleep problems or with a fresh experience of a pandemic-specific dream, resulting in a systemic bias. We also acknowledge that the data analytic steps included human-made decisions, such as harmonizing words and expressions, and classification of dream report content as pandemic or non-pandemic. While the method we applied is completely novel in dream report analysis, it required intensive teamwork and shared decision-making processes. This study did not then allow for the testing of inter-rater reliability. Additionally, the groups with different stress levels were not even in terms of dream report material, as participants with increased stress reported more frequently dreams, and consequently, the data and the related association networks were wider. It is of note that while some cluster networks, especially in the low stress group, were very narrow and easy to label, some cluster networks were wide and partly unfocused. Labeling clusters is based on qualitative interpretations and coming to a consensus on the best fitting label. Yet, the process is fully transparent as all cluster data are openly presented in

the Figure 3

To sum up, we applied a network analysis to explore dream content during COVID-19 lockdown. We found several pandemic-specific dream contents and dream imagery that were associated with a variety of distressing events. A large proportion of the respondents had increased stress, which was

FIGURE 4 | Network analysis parameters according to the perceived stress in panel(A) all respondents, panel(B) in respondents with stress increased, panel(C) in respondents with stress unchanged/lowered. Betweenness is measured as the number of times word X lies on the shortest path between words Y and Z. Degree centrality is simply the sum of direct (i.e., adjacent) edges that each word has with other words. Closeness measures how close a word is to other words and is inversely proportional to the mean shortest distance to all other words.

the COVID-19 pandemic may be that mental health is being impaired around the world.

## MATERIALS AND METHODS

### Crowdsourcing

Figure 5 presents the timeline of the pandemic onset and lockdown in Finland, as well as the timing of our CS survey on sleep. We collaborated with the most widely circulated newspaper in Finland [Helsingin Sanomat (HS), weekly reach of readers  $N = 2$  M, average daily readers  $N = 339,437$ ] to generate broad participation in the very short timeframe of 1 week. The short time window maximized the situational context, which was particularly important for the dream reports. The survey was launched attached to a digital newspaper article on sleep (published April 27, 2020). On January 5, 2020, HS published a reminder that the survey is ongoing and now without paywall. The data were extracted on May 5, 2020, for the analyses. All readers were invited to respond through an internet survey, which gathered data regarding sleep during the COVID-19 lockdown. By filling in the questionnaire, the respondents also

### Treatment of the Dream Content

The respondents were asked the following question: "Describe your dreams during the pandemic lockdown" (which included the consent formulation was as follows: "By filling in the questionnaire, you consent to report your sleep and dreaming to an open space to write). Some respondents wrote two dreams, which were treated as separate reports. While mainstream studies of



FIGURE 5 | Timing of the crowdsourcing survey from the first confirmed COVID-19 case in Finland to May 5, 2020, when the current data were extracted. Light blue indicates the period under lockdown restrictions, including remote schooling and travel restrictions within Finland and abroad. In Finland, individuals were allowed to leave their house freely and spend time outdoors. Gathering size was limited to 10. There were no restrictions relating to outdoor activities, and public transport was available. A period in darker turquoise marks the timing of the data collection.

nightmares and distressing dreams have been used as a priori defined themes. References to coronavirus were retained as thematic grids in the dream content classification (Robert and Zadra, 2014), the current study was purely computational. All dream scripts were reviewed at least twice, and all harmonization decisions were done collectively without any predefined dream-content grids. This method after discussion between five experts. The harmonized dream reports included 4,743 words, out of which 1,095 were unique that has not been used before in dream research. However, before the computational phase, the data were harmonized; for example, changed/lowered and 3,226 and 877 among stress increased instance, dream reports were reduced to word lists containing the essential nouns in the dream report. The dream reports were first transcribed into chronological word lists for each dream as has been done in English text analytics (Kettunen, 2006). We separately. For example, a dream report ("I had tuberculosis and the doctor was angry with me because I did not come to see him when the first symptom appeared") was transcribed on to "tuberculosis-doctor-anger-symptom." After the first draft of panel view. If the resulting dream word clusters included clearly the transcripts was created, synonymous words and the spelling of lockdown or pandemic-specific word associations, the panel format of different words (e.g., shoe vs. shoes) were harmonized. judged the dream as pandemic-specific. The assessment was fully If a word appeared twice in the dream script, it also appeared twice in the harmonized version to maintain the chronological order of the events. In addition to harmonizing the dream scripts in Figure 3.

according to the nouns, harmonizing also involved grouping some word types into categories. For example, all relatives beyond father, mother, grandfather, grandmother, daughter, and son (that were retained as such) were grouped under "relative." Recall of specific cities was grouped under "city," whereas different country names were retained. Synonymous words or expressions were replaced with one chosen word. For example, there were mainly different expressions for "overcrowding," which was the word that we chose in the harmonization process. The original reports were in Finnish, and translation into English required harmonization following steps: (1) we divided the respondents according to as the vocabulary in different languages differs (Finnish: *ihmisiä* [a lot of people], English: *crowd*). Compound words in Finnish were retained as compound words in English, even when the equivalent was not linguistically correct (e.g., *high-risk-group* associations between words by tokenizing each dream with pairs

## Statistical Analyses

We used Bonferroni-corrected one-way analysis of variance in examining sex differences in stress and sleep measures. Spearman correlations were used to study how perceived stress level was associated with self-reported sleep. Pearson's  $\chi^2$  was used to test if the relative frequency of reporting a dream differed between age, sex, and demographic status. The associations between perceived stress level and dream reports were analyzed in the following steps: (1) we divided the respondents according to their perceived stress level into "stress increased" and "stress unchanged/lowered;" (2) we calculated the most frequently used words in dream descriptions in both groups; (3) we analyzed the associations between words by tokenizing each dream with pairs

of adjacent words (dividing each dream description into word pairs); (4) we calculated the frequency of words co-appearing in pairs; (5) we calculated the frequency of words co-appearing in pairs and the pairwise phi correlations/distances between words (Silge and Robinson, 2016). Phi correlation is a common measure for binary correlation. The focus of the phi coefficient is how much more likely it is that either both words X and Y appear, or neither does, than that one appears without the other. In the final step (5), we illustrated these associations separately for correlations of co-appearance, creating networks for the groups with “increased stress” and “stress unchanged/lowered” and estimated both clustering (using Spinglass algorithm) of the words and degree centrality (strength) (Pons and Latapy, 2005). Spinglass algorithm is a community detection algorithm that finds groups of words that are closely connected to each other and tend to co-occur (Reichardt and Bornholdt, 2006). Of the different algorithms, it is particularly suitable for the size of the current dataset (Yang et al., 2016).

The word association networks were also analyzed using statistical indexes. Centrality represents the connectedness of a given node (words) with all the others in the network. Node-strength centrality was defined as the sum of all associations that a given node (word) exhibits with all others in the network (the sum of the weighted number and strength of all connections of a specific node relative to all other nodes) (Freeman, 1978; Valentine and Foreman, 1998). Betweenness and closeness measures are based on the shortest path length (number of connections from node to another) connecting any two nodes (words). A word with high betweenness lies along the shortest path connecting many other words in the network. Thus, the target word would have a high betweenness centrality if it appears in many shortest paths (Freeman, 1977). Closeness is calculated as the reciprocal of the sum of the length of the shortest paths between the node and all other nodes in a network; it is useful for finding the words that are best placed to influence the entire network most quickly. Thus, the more central a node is, the closer it is to all other nodes (Sabidussi, 1966). These analyses were conducted using R 3.6.3 (Pedersen, 2017).

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because the crowdsourcing was performed by Helsinki Sanomat.

## REFERENCES

- American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)*. Washington, D.C.: American Psychiatric Pub.
- Baglioni, C., Nanovska, S., Regen, W., Spiegelhalter, K., Feige, B., Nissen, et al. (2016). Sleep and mental disorders: a meta-analysis of polysomnographic research. *Bull Psychol.* 42, 969–990. doi: 10.1037/bul0000053
- Casagrande, M., Favieri, F., Tambelli, R., and Forte, G. (2020). The enemy who sealed the world: effects quarantine due to the COVID-19 on sleep quality, anxiety, and psychological distress in the Italian population. *Sleep Med*, 12–20. doi: 10.1016/j.sleep.2020.05.011
- Cenat, J. M., Mukunzi, J. N., Noorishad, P. G., Rousseau, C., Derivois, D., Bukaka, J. (2020). A systematic review of mental health programs among populations affected by the Ebola virus disease. *Psychosom. Res.* 11:109966. doi: 10.1016/j.jpsychores.2020.109966
- Freeman, L. C. (1977). A set of measures of centrality based on betweenness. *Sociometry*, 40, 35–41. doi: 10.2307/3033543
- Freeman, L. C. (1978). Centrality in social networks conceptual clarification. *Soc. Networks*, 215–239. doi: 10.1016/0378-8733(78)90021-7
- Giesemann, A., Ait Aoudia, M., Carr, M., Germain, A., Gorzka, R., Holzinger, B., et al. (2019). Aetiology and treatment of nightmare disorder: state of the art and future perspectives. *Sleep Res*, 28:e12820. doi: 10.1111/jsr.2820
- Hartmann, E. (1998). Nightmare after trauma as paradigm for all dreams: a new approach to the nature and functions of dreaming. *Psychiatry*, 61, 223–238. doi: 10.1080/00332747.1998.11024834
- Hartmann, E., and Brezler, T. (2008). A systematic change in dreams after 9/11/01. *Sleep*, 31, 213–218. doi: 10.1093/sleep/31.2.213
- Huang, Y., and Zhao, N. (2020). Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based

who owns the data. Requests to access the datasets should be directed to anukatriina.pesonen@helsinki.fi.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

A-KP as the PI of the study designed the study and data collection, led the dream data preparation, and manuscript writing. JL designed and conducted the network analyses and contributed to manuscript writing. RH and ME prepared the dream data, assisted in statistical analyses, and contributed to manuscript writing. NS contributed to manuscript writing and critically reviewed it. JM-M and MA prepared the dream data and critically reviewed the manuscript. DB critically reviewed the manuscript. HO contributed essentially to the manuscript writing. LK contributed essentially to each stage of the data collection and manuscript writing. All authors contributed to the article and approved the submitted version.

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## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2020.573961/full#supplementary-material>

Supplementary Figure 1 | Percentage of respondents delivering a dream report according to their working status.

- cross-sectional survey *Psychiatry Res* 288:112954. doi: 10.1016/j.psychres.2020.112954
- Kettunen, K. (2006). Developing an automatic linguistic truncation operator for best-match retrieval of Finnish in indexed word form text database and indexes. *J. Inform. Sci.* 32, 465–479. doi: 10.1177/016555150606057
- Klinzing, J. G., Niethard, N., and Born, J. (2019). Mechanisms of systems memory consolidation during sleep. *Nat. Neurosci* 22, 1598–1610. doi: 10.1038/s41593-019-0467-3
- Koulack, D., Prevost, F., and De Koninck, J. (1985). Sleep, dreaming, and adaptation to a stressful intellectual activity. *Sleep* 8, 244–253. doi: 10.1093/sleep/8.3.244
- Li, S. X., Zhang, B., Li, A. M., and Wing, Y. K. (2010). Prevalence and correlates of frequent nightmares: a community-based 2-phase study. *Sleep* 33, 774–780. doi: 10.1093/sleep/33.6.774
- Malinowski, J., and Horton, C. L. (2014). Evidence for the preferential incorporation of emotional waking-life experiences into dream content. *Psychol. Sci.* 24:18. doi: 10.1037/a0036017
- Miller, K. E., Brownlow, J. A., Woodward, S., and Gehrmann, P. R. (2017). Sleep and Dreaming in Posttraumatic Stress Disorder. *Curr. Psychiatry Rep* 19:71.
- Nielsen, T., and Levin, R. (2007). Nightmares: a new neurocognitive model. *Sleep Med. Rev* 11, 295–310. doi: 10.1016/j.smrv.2007.03.004
- Nielsen, T. A., Kuiken, D., Alain, G., Stenstrom, P., and Powell, R. A. (2004). Immediate and delayed incorporations of events into dreams: further replication and implications for dream function. *Sleep* 27, 327–336. doi: 10.1111/j.1365-2869.2004.00421.x
- Nielsen, T. A., Stenstrom, P., and Levin, R. (2006). Nightmare frequency as a function of age, gender, and September 11, 2001: findings from an Internet questionnaire. *Dreaming* 16:145. doi: 10.1037/1053-0797.16.3.145
- Pedersen, T. L. (2017). Cgraph: an Implementation of Grammar of Graphics for Graphs and NetworkX package version 0.1, 1.
- Peigneux, P., Laureys, S., Fuchs, S., Destrebecqz, A., Collette, F., Delbeuck, X., et al. (2003). Learned material content and acquisition level modulate cerebral reactivation during posttraining rapid-eye-movements sleep. *Neuroimage* 20, 125–134. doi: 10.1016/s1053-8119(03)00278-7
- Pons, P., and Latapy, M. (2006). Computing Communities in Large Networks Using Random Walks. *Berlin: Springer*.
- Reichardt, J., and Bornholdt, S. (2006). Statistical mechanics of community detection. *Physical. Rev. E* 74:016110.
- Revonsuo, A. (2000). The reinterpretation of dreams: an evolutionary hypothesis and relationship to well-being. *J. Abnorm. Psychol.* 109, 273–281. doi: 10.1037/10021-843x.109.2.273
- Robert, G., and Zadra, A. (2014). Thematic and content analysis of idiopathic nightmares and bad dreams. *Sleep* 37, 409–417. doi: 10.5665/sleep.3426
- Russell, K., Allan, S., Beattie, L., Bohan, J., MacMahon, K., and Rasmussen, S. (2019). Sleep problem, suicide and self-harm in university students: a systematic review. *Sleep Med. Rev* 44, 58–69. doi: 10.1016/j.smrv.2018.12.008
- Sabidussi, G. (1966). The centrality index of a graph. *Psychometrika* 31, 581–603. doi: 10.1007/bf02289527
- Sandman, N., Valli, K., Kronholm, E., Ollila, H. M., Revonsuo, A., Laatikainen, T., et al. (2013). Nightmares: prevalence among the Finnish general adult population and war veterans during 1972–2007. *Sleep* 36, 1041–1050. doi: 10.5665/sleep.2806
- Sandman, N., Valli, K., Kronholm, E., Revonsuo, A., Laatikainen, T., and Paunonen, T. (2015). Nightmares: risk factors among the Finnish general adult population. *Sleep* 38, 507–514. doi: 10.5665/sleep.4560
- Schredl, M. (2010). Nightmare frequency and nightmare topics in a representative German sample. *Eur. Arch. Psychiatry Clin. Neurosci* 260, 565–570. doi: 10.1007/s00406-010-0112-3
- Schredl, M., and Hofmann, F. (2003). Continuity between waking activities and dream activities. *Conscious Cogn* 12, 298–308. doi: 10.1016/s1053-8100(02)00072-7
- Siglar, F., Baird, B., Perogamvros, L., Bernardi, G., LaRocque, J. J., Riedner, B., et al. (2017). The neural correlates of dreaming. *Nat. Neurosci* 20, 872–878. doi: 10.1038/nn.4545
- Stige, J., and Robinson, D. (2016). tidytext: text mining and analysis using tidy data principles in R. *J. Open Source Softw* 3:7. doi: 10.21105/joss.00037
- Solomonova, E., Stenstrom, P., Paquette, T., and Nielsen, T. (2015). Different temporal patterns of memory incorporations into dreams for laboratory and virtual reality experiences: relation to dreamed locus of control. *J. Dream Res* 8, 10–26.
- Stickgold, R., Malia, A., Maguire, D., Roddenberry, D., and O'Connor, M. (2000). Replaying the game: hypnagogic images in normals and amnesics. *Science* 290, 350–353. doi: 10.1126/science.290.5490.350
- Tedeschi, D., Socci, V., De Gennaro, L., and Ferrara, M. (2018). Sleep and emotional processing. *Sleep Med. Rev* 40, 183–195. doi: 10.1016/j.smrv.2017.12.005
- Valente, T. W., and Foreman, R. K. (1998). Integration and radiality: measuring the extent of an individual's connectedness and reachability in a network. *Networks* 20, 89–105. doi: 10.1016/s0378-8733(97)00007-5
- Waterman, D., Elton, M., and Kenemans, J. L. (1993). Methodological issues affecting the collection of dreams. *Sleep* 16, 8–12. doi: 10.1111/j.1365-2869.1993.tb00053.x
- Windt, J. M. (2010). The immersive spatiotemporal hallucination model of dreaming. *Phenomenol. Cogn. Sci.* 9:295–316. doi: 10.1007/s11097-010-9163-1
- World Health Organization. (2020). WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-11 March 2020. Geneva: World Health Organization.
- Xiao, H., Zhang, Y., Kong, D., Li, S., and Yang, N. (2020). Social capital and sleep quality in individuals who self-isolated for 14 days during the Coronavirus disease 2019 (COVID-19) outbreak in January 2020 in China. *Front. Med. Sci. Monit.* 26:e923921.
- Yang, Z., Algesheimer, R., and Tessone, C. J. (2016). A comparative analysis of community detection algorithms on artificial networks. *Sci. Rep* 6:30750.
- Zadra, A., and Donderi, D. C. (2000). Nightmares and bad dreams: their prevalence and relationship to well-being. *J. Abnorm. Psychol.* 109, 273–281. doi: 10.1037/10021-843x.109.2.273
- Zhou, J., Liu, L., Xue, P., Yang, X., and Tang, X. (2020). Mental health response to the COVID-19 outbreak in China. *Am. J. Psychiatry* 177, 574–575. doi: 10.1176/appi.ajp.2020.20030304